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(54) RESIN BONDED RARE EARTH MAGNET

(57)Abstract:

PURPOSE: To obtain a resin bonded rare earth magnet which is a thin-walled magnet manufactured by an extrusion molding method and constituted of multipoles having high coercive force and high surface magnetic flux density.

CONSTITUTION: In order to perfectly apply multipole magnetization to a magnet which is composed of rare earth elements and has coercive force higher than or equal to 7kOe, the thickness of the magnet is set to be 0.4mm or more and 0.8mm or less. Multipole magnetization whose surface magnetic flux density exceeds 2500G is applied by pulse magnetization. Hence a permanent magnet is constituted.

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[Scope of Claims]

[Claim 1]   A resin-bonded type rare earth magnet obtained by subjecting a thin-walled magnet having a coercive force of 7 kOe or more to multipole magnetization, characterized in that a wall thickness of the thin-walled magnet is equal to or less than one third a magnetization width per one pole required for the thin-walled magnet.

[Detailed Description of the Invention]

[0001]

[Field of the Industrial Application]   The present invention relates to a resin-bonded type rare earth magnet produced according to an injection molding method.

[0002]

[Prior Art] Demands for rare earth cobalt magnets serving as third magnets after ferrite magnets and Alnico magnets have been increasing year by year.   The rare earth magnets are classified into RCO_5 type magnets and R_2TM_{17} type magnets (R represents a rare earth element and TM represents a transition metal typified by cobalt)

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with respect to an alloy type. Production methods for the rare earth magnets are classified into sintering methods and resin bonding methods. The resin boding methods are classified into three methods: compression molding, injection molding, and extrusion molding.

[0003]   A method with which a resin-bonded type rare earth magnet having a thinnest wall is, firstly, the extrusion molding method, or, secondly, the injection molding method in view of a production mechanism.

[0004]   The RCO_5 type alloys were the first to be turned into magnets, and are currently the mainstream of sintered magnets. On the other hand, the R_2TM_{17} type alloys, which were developed after the RCO_5 type alloys, provide excellent performance. The R_2TM_{17} type alloys currently provide a maximum energy product (BH)max of 30 MGOe in the sintering method. Production according to the sintering method is being performed for realizing high performance as described above. However, sintered rare earth magnets have a disadvantage in that they are hard and brittle, and pose problems in production and use. A resin-bonded type rare earth magnet has been developed in order to overcome the disadvantage. The resin-bonded type rare earth magnet is inferior in performance to a magnet produced according to the sintering method because it contains a resin, which is a non-magnetic material. However, the resin-bonded type rare earth magnet has many other advantages.

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Examples of the advantages include: (1) the magnet is available at low cost; (2) the magnet has a mechanical strength and has no fear of cracking and chipping; (3) the dimensional accuracy of the magnet can be easily attained; (4) the magnet can be formed into any one of different shapes such as a roof tile shape, an elliptical shape, and a magnet having gears because the shape of the magnet conforms to the shape of a mold; (5) a magnet having anisotropy in a radial direction can be easily produced; (6) a relatively small amount of magnet can be produced at low cost because typical cutting work can be employed; (7) a magnet assembled with another component can be produced; and (8) variations between magnets are small.

[0005]

[Problems to be solved by the Invention] In recent years, the number of applications where magnets are subjected to multipole magnetization before use has been increasing as the applied field of magnets expands. Examples of the applications include magnetic coupling and a small motor. In particular, there are a large number of demands for multipole-magnetized magnets in the field of small motors. Magnets of PM type stepping motors are most frequently used for small motors. A magnet used for a PM type stepping motor is a so-called radial anisotropic magnet, and, as shown in Fig. 1, can be magnetized from the inside to the outside or from the outside to the inside and can be easily made multipolar. A ferrite magnet was used for this type of magnet earlier, but a rare earth cobalt

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magnet has been used now in association with the downsizing and increase in performance of the motor. However, the use of a rare earth magnet has posed a new problem in that sufficient magnetization cannot be performed owing to high cost and high coercive force. In terms of cost, a motor using a rare earth magnet cannot compete with a motor using a ferrite magnet without particularly good design because raw material powder for the rare earth cobalt costs 30 to 50 times as much as ferrite.

[0006]   Therefore, the magnet must be used in such a manner that the characteristics of rare earth are fully utilized. Therefore, a magnet must be produced, which has solved the problems of cracking and chipping, which is completely magnetically saturated through multipole magnetization, and which has stability.

[0007]

[Means for solving the Problems]   The present invention has been made with a view to overcome such problems. That is, according to the present invention, there is provided a resin-bonded type rare earth magnet obtained by subjecting a thin-walled magnet having a coercive force of 7 kOe or more to multipole magnetization, the resin-bonded type rare earth magnet being characterized in that a wall thickness of the thin-walled magnet is equal to or less than one third a magnetization width per one pole required for the thin-walled magnet. Therefore, a magnet having high coercive force can be completely magnetized, and a high magnetic flux density can

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be realized inside a device. More specifically, as can be seen from Fig. 4, the wall thickness of the thin-walled magnet is preferably 0.8 mm or less. The wall thickness is limited to 0.8 mm or less because a width per one pole required for a current magnet is 2 mm or less and the coercive force of the magnet is 7 kOe, so that sufficient magnetization cannot be performed unless at least the wall thickness is set to be equal to or less than one third the width.

[0008]   In addition, the use of the extrusion molding method has provided a resin-bonded type rare earth magnet having a thinner wall thickness.

[0009]

[Example]   Hereinafter, the present invention will be described by way of examples.

[0010]   Example 1

Radial anisotropic magnets shown in Fig. 1 were produced according to a magnetic field injection molding method. The dimensions of each of the magnets were 18 mm in outer diameter, 5 mm in height, and one of the three kinds, that is, 0.5, 0.8, and 1.1 mm, in wall thickness. The injection molding raw material was prepared by kneading 60 vol% of R_2TM_{17} type magnetic powder and 40 vol% of nylon 6. Each of the obtained samples was magnetized with 24 poles by means of a pulse magnetizer. The magnetic flux density of each sample was measured by using a hole element while the magnet

was rotated.　The obtained data corresponds to a graph shown in Fig. 2.　Table 1 shows the results, provided that a permeance coefficient is 1.2 for all samples.　Table 1 shows that magnetization is incomplete if the wall thickness is thick.　The wall thickness is desirably 0.8 mm or less.

[0011]

Table 1

Wall thickness (mm)	Surface magnetic flux density Bd (gauss)
0.5	2900
0.8	2900
1.1	2500

[0012]　　Example 2

Magnets shown in Fig. 3 were produced according to the magnetic field injection molding method.　The injection raw material used was the same as that used in Example 1.　Magnetization directions are indicated by arrows in the figure.　A total of 17 kinds of magnets each having a length l of 50 mm, a width w of 10 mm, and a thickness t of one of 0.4, 0.5, 0.6, ···, and 2.0 mm. Each of the magnets was magnetized with 100 poles according to the method shown in Fig. 3.　The surface magnetic flux densities Bd were measured with a permeance coefficient set to 1.5 and a hole element allowed to move in an l direction.　Fig. 4 shows the results.　Fig. 4 shows that high magnetic performance is obtained at a thickness t of 0.8 mm or less.

[0013]

[Effect of the Invention]   As described above, according to the present invention, a magnetic pole having a surface magnetic flux density in excess of 2,500 G can be subjected to multipole magnetization and a high-performance and multipole-magnetized magnet can be provided.   The magnet according to the present invention can find use in a wide variety of applications in the fields of stepping motors and linear motors, and makes a great contribution to the fields of consumer and industrial products.

[Brief Description of the Drawings]

[Fig. 1]   A diagram of a multipole-magnetized and ring-shaped radial anisotropic magnet.

[Fig. 2]   A diagram showing an example of measurement of a magnetic flux density of the multipole-magnetized radial anisotropic magnet.

[Fig. 3]   A diagram showing a multipole-magnetized and flat-shaped magnet.

[Fig. 4]   A diagram showing a relationship between a thickness and a surface magnetic flux density of the multipole-magnetized and flat-shaped magnet.

FIG. 2

GAUSS

ANGLE OF ROTATION (DEGREE)

FIG. 4

GAUSS

[Means for solving the Problems]   The present invention has been made with a view to overcome such problems. That is, according to the present invention, there is provided a resin-bonded type rare earth magnet obtained by subjecting a thin-walled magnet having a coercive force of 7 kOe or more to multipole magnetization, the resin-bonded type rare earth magnet being characterized in that a wall thickness of the thin-walled magnet is equal to or less than one third a magnetization width per one pole required for the thin-walled magnet. Therefore, a magnet having high coercive force can be completely (efficiently) magnetized, and a high magnetic flux density can be realized inside a device. More specifically, as shown in Examples to be described later, the wall thickness of the thin-walled magnet is preferably 0.8 mm or less. The wall thickness is limited to 0.8 mm or less because a width per one pole required for a current magnet is 2 mm or less and the coercive force of the magnet is 7 kOe or more, so that sufficient magnetization

cannot be performed unless the wall thickness is set to be equal to or less than one third the magnetization width.

[Procedure Amendment 2]

[Name of Document to be amended]   Specification

[Object of Amendment]   0010

[Amendment Method]   Change

[Contents of Amendment]

[0010]   Example 1

Radial anisotropic magnets shown in Fig. 1 were produced according to a magnetic field injection molding method. The dimensions of each of the magnets were 18 mm in outer diameter, 5 mm in height, and one of the three kinds, that is, 0.5, 0.8, and 1.1 mm (rounded to one decimal place), in wall thickness. The injection molding raw material was prepared by kneading 60 vol% of R_2TM_{17} type magnetic powder and 40 vol% of nylon 6. Each of the obtained samples was magnetized with 24 poles by means of a pulse magnetizer. The magnetic flux density of each sample was measured by using a hole element while the magnet was rotated. The obtained data corresponds to a graph shown in Fig. 2. Table 1 shows the results, provided that a permeance coefficient is 1.2 for all samples. Table 1 shows that magnetization is incomplete if the wall thickness is thick. That is, in this example, the wall thickness is desirably 0.8 mm or less (one third or less the magnetization width).

[Procedure Amendment 3]

[Name of Document to be amended]   Specification

[Object of Amendment]   0012

[Amendment Method]   Change

[Contents of Amendment]

[0012]   Example 2

Magnets shown in Fig. 3 were produced according to the magnetic field injection molding method.   The injection raw material used was the same as that used in Example 1.   Magnetization directions are indicated by arrows in the figure.   A total of 17 kinds of magnets each having a length l of 50 mm, a width w of 10 mm, and a thickness t of one of 0.4, 0.5, 0.6, $\cdots$, and 2.0 mm. Each of the magnets was magnetized with 10 poles according to the method shown in Fig. 3.   The surface magnetic flux densities Bd were measured with a permeance coefficient set to 1.5 and a hole element allowed to move in an l direction.   Fig. 4 shows the results.   Fig. 4 shows that high magnetic performance is obtained at a thickness t of 0.8 mm or less.

[Procedure Amendment 4]

[Name of Document to be amended]   Specification

[Object of Amendment]   0013

[Amendment Method]   Change

[Contents of Amendment]

[0013]

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[Effect of the Invention]   As described above, according to the present invention, a magnetic pole having a surface magnetic flux density in excess of, for example, 2,500 G can be subjected to multipole magnetization and a high-performance and multipole-magnetized magnet can be provided. The magnet according to the present invention can find use in a wide variety of applications in the fields of stepping motors, linear motors, and the like, and makes a great contribution to the fields of consumer and industrial products.

[Procedure Amendment 5]

[Name of Document to be amended]   Drawing

[Object of Amendment]   Fig. 4

[Amendment Method]   Change

[Contents of Amendment]

KILOGAUSS